MODELING FLOW AND TRANSPORT IN UNSATURATED FRACTURED POROUS MEDIA

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RESEARCH OBJECTIVES

Modeling flow and transport in unsaturated fractured rocks is of interest in many areas, including geological disposal of nuclear wastes and subsurface contaminant transport. Because the continuum modeling approach is relatively simple and straightforward to implement, it is preferred for most applications that are encountered in practice. However, its usefulness for representing gravity-driven fingering flow and transport in unsaturated fractured rocks has often been questioned. The main objective of this study is to evaluate the continuum approach based on a combination of model calibration and prediction.

APPROACH

Data from an infiltration and tracer transport test carried out in a densely fractured rock were used in this study. The active fracture model was employed to handle the fingering flow and transport, and the MINC and an analytical approach used to capture the transient flow and transport between fractures and the matrix. The corresponding numerical model, calibrated with seepage data obtained from the early stage of the infiltration test, was used to predicate seepage rates at the late stage. The model was further calibrated with all the seepage data and then employed to predict observed tracer transport results. The simulation results and the data were compared to evaluate the usefulness and limitations of the continuum approach.

ACCOMPLISHMENTS

While more theoretical, numerical and experimental studies are needed to provide a more conclusive evaluation, the comparison between the simulated and observed results suggests that the continuum approach is practically valid for modeling flow and transport in the unsaturated fractured rocks. It was also found that the use of the active fracture model can approximately handle the average behavior of fingering flow and transport, and the matrix diffusion has a significant effect on the transport process in unsaturated fractured rocks.

SIGNIFICANCE OF FINDINGS

The continuum approach is commonly used for modeling complex flow and transport processes in unsaturated fractured rocks. This study reports a unique evaluation of this approach using field observations directly related to flow and transport. The positive evaluation results provide further confidence for the use of the continuum approach in modeling flow and transport in the unsaturated zone of Yucca Mountain, Nevada, potential site of a high-level nuclear waste repository.
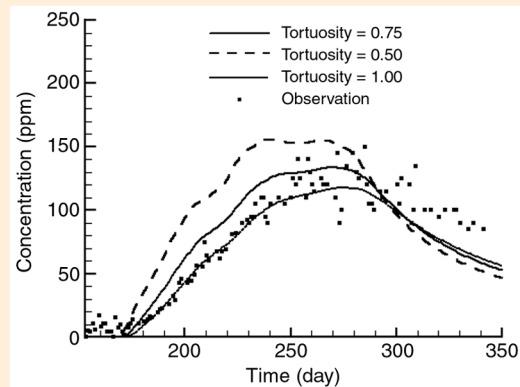

Figure 1. Comparison between the observed tracer concentrations and modeling results for different matrix tortuosities.

RELATED PUBLICATIONS

Liu, H.H., C. Doughty and G.S. Bodvarsson, An active fracture model for unsaturated flow and transport in fractured rocks, Water Resources Research, 29 (12), 2633-2646, 1998.

Liu, H.H., C.B. Haukwa, R. Ahlers and G.S. Bodvarsson, Modeling flow and transport in unsaturated fractured rocks: An evaluation of the continuum approach, Water Resources Research, in review.

ACKNOWLEDGEMENTS